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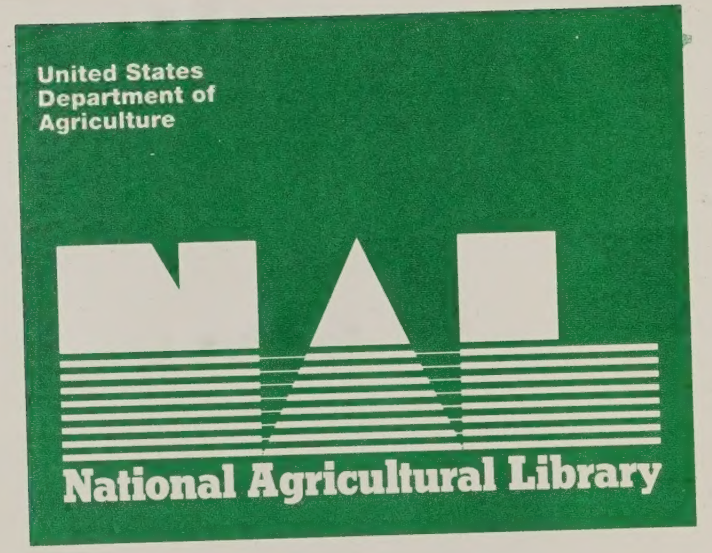
Accomplishments of Agricultural Research Service



Issued August 1982

AGRICULTURAL RESEARCH ACCOMPLISHMENTS

We are describing, in these pages, a fraction of the agricultural research accomplishments that are the product of Agency scientists and engineers over the last three years.

Agency research is directed to answering national needs--from assuring adequate food supplies to safeguarding natural resources, improving the nutrition of people, strengthening the country's international market and balance of payments, and understanding geographic, climatic and environmental influences on agriculture.

We are pleased to report among the following accomplishments some scientific discoveries that are the result of years of basic research; such is the case for the new foot-and-mouth vaccine to protect animals. Other accomplishments reflect the results of on-going research that continually build on the country's base of knowledge in the agricultural and food sciences.

T. B. Kinney, Jr.

Terry B. Kinney, Jr.
Administrator
Agricultural Research Service

TABLE OF CONTENTS

RECENT RESEARCH ACCOMPLISHMENTS IN SOIL, WATER, AND AIR SCIENCES

Hand-Held Instrument Developed for Measuring Soil Salinity

Agricultural Research Service (ARS) scientists at Riverside, California, have developed a hand-held electromagnetic device that determines the degree of soil salinity and eliminates the need for laboratory analyses of soil samples. Salinity problems are becoming increasingly important in arid and semiarid areas as available water supplies for agricultural irrigation diminish, irrigation water is degraded, and greater control and reuse of moderately saline return flows are required.

The hand-held measuring device was developed during research designed to develop efficient management practices that will increase or maintain high agricultural productivity and protect the quality of the natural resource base. As the device is held at various heights above the soil surface, it provides instantaneous readings, thereby enabling workers to map soil-salinity profiles in the field. The method is convenient, rapid, and reasonably accurate. It has excellent potential for use in monitoring changes in salinity level, making salinity inventories, identifying saline-seep areas and brackish groundwater, and studying other soil or groundwater salinity problems.

New, Low-Cost, Automatic Furrow-Irrigation System Developed

The primary purpose of irrigation and drainage is to increase and stabilize crop yields where excesses or deficiencies of water exist. A totally new concept was used by ARS in developing a system for transporting and distributing water to irrigation furrows. This system is unique in that it has a single pipeline--a common plastic irrigation pipe--and provides for low-cost, automatic control of water to individual furrows via a moving plug controlled by a battery-powered motor. A computer model of the system, also developed by ARS, allows rapid determination of optimum pipe and orifice sizes. When the system is used with a water reuse system, very high water application efficiencies and uniformities can be expected.

Tillage Systems Developed for Improving Farming Practices and Soil-Erosion Control

Each year the United States loses about 5.5 billion tons of topsoil, a problem that is one of the most critical in American agriculture today. If losses from soil erosion continue unabated, our physical capacity to produce food and fiber efficiently will be severely threatened. The proper management of nitrogen fertilizer and crop residues by good tillage practices will not only help control soil erosion, but also contribute to optimum cycling of plant nutrients.

ARS, in cooperation with other Federal and State cooperating agencies, developed a nationwide program for

nitrogen and tillage research. As a result of the research, farmers across the Nation now have available the technology base necessary for using improved methods of soil management to increase the efficiency of fertilizer and fuel use and to control soil erosion and environmental degradation. The new and practical systems developed offer the best potential for controlling erosion and restoring marginal land on America's 2.5 million farms. Based on the results of the nitrogen and tillage research, farmers are using systems that incorporate a wide array of conservation-management practices--minimum or no-tillage systems, contour or strip cropping, terracing, minimum or partial removal of crop residues, crop rotation, herbicides for weed control, and others. In ARS experiments, researchers found that leaving 3 tons of crop residue per acre on the field reduced soil erosion loss 85 percent. They also found that where the no-till system was practiced in soybeans, only 0.13 ton of soil per acre eroded, compared with 12.92 tons from tilled soil. In 1980, American farms used no-till and other forms of conservation tillage on 60 million acres of cropland.

Daylength Controlled Time of Winter-Wheat Heading at Low Latitudes

ARS research determined that daylength, instead of temperatures, is the controlling factor in the time of winter-wheat heading at low latitudes. Before this research, the cause for low production of winter wheat at latitudes below about 30°N was commonly thought to be insufficient cold to vernalize the plants. However, when the important winter-wheat cultivars of the Great Plains (latitude about 42°N) were planted in Weslaco, Texas (latitude 26°N), and studied for two seasons, the plants did not change from vegetative to reproductive growth until about March 1, when daylength had increased to at least 12 hours. By then, temperature was high, the plants senesced rapidly, and kernels had shriveled. Therefore, daylength, and not temperature, had controlled heading. This finding suggests that the incorporation, into winter wheat, of genes that reduce photosensitivity by about 45 minutes could extend the southern border of the winter-wheat production area as much as 300 kilometers.

Technology Developed for Reclaiming Western Strip-Mined Land

ARS research is devoted to developing technologies by which plans for reclamation and land use can be integrated into mining plans so that disturbed areas can be restored, stabilized, and maintained for productivity and conservation values.

ARS developed several methods for restoring productivity to mined areas. Of the methods developed, the one found to be

best was to save and return to the leveled soils about 24 inches of subsoil and 6 inches of topsoil. In ARS studies conducted in North Dakota, animals were grazed on mined, reclaimed land that had been seeded to introduce grass species; and on adjacent, unmined land that was native range in good-to-excellent condition. Results indicated that forage production and animal performance were equal on the reclaimed and the unmined land when both were grazed at the same intensity and used as spring and early-summer pastures. In studies conducted in Montana and Wyoming, forage samples from reclaimed sites were analyzed, and the analyses revealed no evidence of heavy metals, thus allaying any fear that heavy metals would enter the food chain through this source. As a result of this research, North Dakota and neighboring States enacted legislation that incorporated the results of this research into technical standards for approved methods of reclamation. The ARS research that led to this legislation provides the technology needed by regulatory agencies, mine operators, and others in planning and assessing the reclamation of disturbed areas.

Conservation Tillage Increases Nitrogen-Fertilizer-Use Efficiency During Times of Soil-Water Stress

The results of a 4-year study by ARS scientists, in which conservation tillage was compared with conventional tillage for corn-silage production, indicated that yields, nitrogen uptake from soil and fertilizer, and percentage of nitrogen-fertilizer recovery were greater under conservation tillage than under conventional tillage during years of soil-water stress. In years of adequate rainfall, these factors were unaffected by tillage. These findings have great significance to farmers whose production of plants and animals relies in large measure on climatic and environmental fluctuations--conditions over which they have no control. Thus, the use of conservation tillage as a regular practice has excellent potential for assuring adequate levels of productivity during periods of climatic and environmental stress, as well as during periods of adequate rainfall.

Mathematical Model Developed That Predicts the Effect of Pollution-Control Practices on Water Quality

A field-scale model entitled "Chemicals, Runoff, and Erosion From Agricultural Management Systems (CREAMS)" was developed by ARS to assess the effect of best-management practices for control of nonpoint source pollution on the movement of sediment, fertilizer, nutrients, and pesticides from cultivated fields. The model reflects a balance between accuracy of prediction and operational costs. Inputs include daily precipitation, solar radiation, and air temperature; land use; management practices; and the timing and rates of application of agricultural chemicals. These inputs are integrated into the simulated watershed system, together with

data on soils and on geology and topography, and transformed into the following outputs: Evapotranspiration, surface runoff, percolation, erosion and sedimentation, and agricultural-chemical movement. The outputs provide helpful information to farmers and land use planners on the effects of pollution-abatement practices on water quality. The model can be used to compare various practices for minimizing the movement of agricultural chemicals and sediments from agricultural lands so that the most effective practices can be selected. It can also be used to indicate the effect of different management practices on erosion control and fertilizer-use efficiency. The model is being used nationally and internationally and is being expanded to include the routing of chemicals and sediment through watersheds and river basins.

Guide Developed for Predicting Sheet and Rill Erosion on Forest Land

Practices for managing forest soils vary substantially in their effect on productivity and erosion. Erosion must be minimized for effective management of forest soils. However, work to minimize soil erosion requires a knowledge of the factors that control soil losses. Working cooperatively with the U.S. Forest Service, ARS scientists successfully adapted the Universal Soil Loss Equation (USLE) for use on forest lands. They modified the cover-management factor in the equation to accommodate the unique characteristics of the forest environment. The characteristics accommodated were ground-cover litter, slash, logs, and surface rock; forest canopy; soil reconsolidation, high organic-matter content, and a dense mat of fine roots in the surface layer; and high aggregate stability. The modified equation provides a valuable tool for use by those charged with managing and developing the Nation's forests for multiple use.

Field Manual Developed for Research in Agricultural Hydrology

A multidisciplinary team of scientists published a manual ("Field Manual for Research in Agricultural Hydrology", Agriculture Handbook No. 224, SEA, USDA) that describes the experimental procedures to be followed in initiating and maintaining research projects aimed at determining the hydrologic response of agricultural watersheds. The manual was well received by several Federal agencies and by professional engineers in the United States and elsewhere. The need for good cause-and-effect data was identified by the U.S. General Accounting Office as one of the highest national priorities for formulating water-quality strategies and for developing effective water-quality control programs. The information made available in this handbook should materially assist State and Federal agencies in setting up technically sound watershed monitoring programs and, thereby, ensure that

policy and planning decisions are based on defensible hydrologic and water-quality data.

Estimates of Solar Radiation Compared With Ground-Level Observations

An atmospheric radioactive transfer model and an energy balance model were applied to operational meteorological satellite data of scene brightness and cloud amount. The field data collection was coordinated by ARS with data collected by ARS, the State agricultural experiment stations, and the National Environmental Satellite Service of the National Oceanic and Atmospheric Administration (NOAA) during a 63-day test. Correspondence between model predictions and ground observations was good and demonstrated the potential for an operational system for estimating solar radiation. This system is now operational by NOAA, providing solar radiation for the United States east of the Rocky Mountains. An operational solar radiation evaluation system is essential for calculating energy use, evapotranspiration, crop growth, drought, and other physical environmental factors that affect agricultural production efficiency.

Citrus Hybrids Can Survive Subfreezing Temperatures

Florida citrus crops suffered substantial damage during the winter freezes of 1981 and 1982, with predictable losses for producers and price increases for consumers. From distant relatives of citrus originating in Australia and China, ARS scientists have developed new hybrids with our citrus that tolerate the cold. At subfreezing temperatures, those hybrids exhibited little or no damage, while commercial varieties were killed. Cold-tolerant citrus trees developed by genetic manipulation could counter the threat posed by occasional spells of subfreezing weather in citrus-producing areas.

New Varieties of Potatoes for Different Areas Resist Pests and Make Good Chips or Fries

The eastern potato breeding and genetics research program illustrates the benefits of cooperative research. This 70-year-old program has developed a broad-based, genetically diverse inventory of germplasm and breeding materials. Cooperative efforts with the States of Maine, New York, New Jersey, Pennsylvania, Virginia, North Carolina, Florida, and Michigan have developed 8 multipest-resistant potato varieties for the East Coast and other areas.

Atlantic (released in 1977) and Belchip (released in 1978) are improved, high-solids varieties for premium quality potato chips. BelRus (released in 1978), the first russet variety adapted to the diverse growing conditions of the Eastern United States, is primarily a baking potato but also is suitable for long, high-quality frozen french fries. Delta Gold, a new yellow-fleshed type with high quality and high solids (released in 1979), should provide Northeast producers with seed and table stock for export to countries that prefer yellow-fleshed potatoes. Russette (released in 1980) is a new multiple-use, russet-skinned variety that grows well in Florida and the Northeastern States and might be adapted to the Midwest. Pennrose, Oceania, and Chipbelle were released in 1981. Pennrose is a red-skinned, high-yielding fresh market variety. Oceania is an early, high-quality, multipest-resistant variety with wide adaptation for the fresh market trade. Chipbelle, a sister selection of Atlantic and Belchip, has excellent chipping quality, even without conditioning, directly from extended storage at 45°F.

From superior germplasm now under development, other new russet clones are expected. They should be of high quality, widely adapted, and resistant to several pests, including golden nematode. They are expected to comprise at least 50 percent of the potato acreage in the Northeast and other Eastern States by 1990.

One objective for superior germplasm development would be a new processing potato that could be harvested at low temperature (36°F), immediately stored at 40°F until the following April or later, and processed, without conditioning the tubers, directly from storage into chips. With such a variety, growers in northern areas could produce potato stocks for processing, with minimum storage losses, and profitably deliver a high-quality product.

New Pest-Resistant Ornamental Plants Adapt to Environment

New floral and nursery crop plants with pest resistance and environmental adaptability have been developed by ARS scientists. These new types are designed to meet the changing needs of homeowners and industry and to provide new landscaping interest and possibilities.

Multiple-disease resistance to scab and fire blight has been achieved with the introduction of two pyracantha varieties: 'Navaho', a dwarf, semievergreen plant with luminescent orange-red fruit that remain on the plant throughout most of the winter; and 'Titon', with a distinct upright growth habit, medium green foliage, and light yellow fruit that mature and persist until January. New viburnum cultivars include: 'Shasta', with a spectacular mass of white flowers, scarlet fruit, and intense plum-colored autumn foliage; 'Chesapeake', with glossy, dark green foliage, and good autumn color; and 'Eskimo', for use as a specimen, a hedge, or mass planting. 'Tuscarora', 'Muskogee', and 'Natchez' are new, mildew-resistant crape myrtles; and 'Galaxy' and 'Nimbus' are new magnolias with superior ornamental characteristics well adapted for nursery and landscape use. 'Cardan' is a new green ash tree for windbreak and conservation plantings. 'Union', a Fusarium wilt-resistant mimosa, was developed and released jointly with the Georgia Agricultural Experiment Station. 'Dakota Surprise', a cinquefoil (Potentilla) shrub, with bright yellow flowers, is resistant to drought, and adapted to the Northern Great Plains for foundation and border plantings. 'Helene', a new multistemmed, densely branched hibiscus shrub, combines polyploid sterility with superior ornamental characteristics.

Two new fireblight-resistant ornamental pears provide an alternative to the popular 'Bradford' pear. One cultivar, 'Whitehouse', has a narrow columar crown; and a second cultivar, 'Capital', also has a slender growth habit, similar to that of the Lombardy poplar, for use as an ornamental screen or windbreak.

The new camellias released extend both the northern and southern ranges of adaptation. These include 'Frost Prince' and 'Frost Princess' that are cold-hardy and 'Two Marthas' that tolerate heat and high light intensity. 'Ack-Scent' is the first of a series of new fragrant-scented camellia varieties.

'Amazon' is a new type of container-grown herbaceous perennial flowering plant of Chrysothemis pulchells; 'Para Pink', for beds and hanging baskets, is a new herbaceous annual flowering plant of Torenia fournieri; and 'Spotless Gold', 'Spotless Yellow', and 'Spotless Pink' are three new blackspot-resistant breeding lines of roses.

Corn and Sorghum Improved by Breeding

ARS scientists developed a system for more accurately determining differences among corn genotypes in their susceptibility to infection by Aspergillus flavus, a fungus that produces aflatoxin. They designed a "pin bar," a metal bar with attached pins which can be inserted through the corn husk into the kernel, and used it to inoculate developing kernels on ears of corn with the fungus. Inoculated and adjacent kernels later were removed and assayed for A. flavus; level of infection was compared among several corn hybrids. The relative level of infection estimated the relative resistance of the hybrids to A. flavus. In comparison with other means of inoculation, the pin bar gave more consistent data from year to year. Tests of corn hybrids with pin-bar inoculation might enable breeders to select genotypes of corn that would resist infection by A. flavus and thus provide some control of aflatoxin contamination.

Diversity in cytoplasmic characteristics was discovered and described for lines of sorghum that differ in male sterility. Mitochondrial DNA differences were consistent with fertility differences. In addition, plasmid-like molecules were found in the cytoplasm of one line. These studies provide additional opportunities to reduce genetic vulnerability of sorghum hybrids to environmental and biological hazards, and they enhance the possibilities for successful recombinant DNA research.

New, Short, High-Yielding Rice Varieties Increase Rice Production in California

A short-stature (semidwarf), high-yielding rice mutant genotype was developed in California in a cooperative research program among ARS, the California Agricultural Experiment Station, and industry. The mutant type was selected before 1979 but only recently was actually incorporated into the new rice plant type and tested. Four

new, short, high-yielding varieties, released within the past 3 years, have markedly increased the average yield of rice in California. All four have the mutant short stature associated with high yield. Breeding rice for short stature is an example of tailoring a crop to the environment. The new varieties, with their short stature and strong straw, respond to extra fertilizer without producing the extra height that is associated with lodging in heavily fertilized tall varieties. Extensive planting of the commercial varieties developed by use of the mutant short-stature germplasm has significantly increased rice production in California.

Wild Germplasm Cuts Cotton's Appeal to Bugs

ARS scientists have developed nectariless cottons that suppress certain insect pests and thus reduce the need for chemical pesticides. A wild Hawaiian species of cotton lacks extrafloral nectaries, which secrete a honey-like substance (nectar) that attracts and provides food for certain insects. The wild species, however, does not produce marketable fiber and is unadapted to the cotton-growing areas of the United States. Research by ARS scientists led to the genetic control of those deficiencies and to the development of procedures for transferring the nectariless trait into domestic cultivated cottons. Noncommercial germplasm stocks, combining the nectariless characteristic with acceptable fiber properties and adaptation to our Cotton Belt, were cooperatively developed and released by ARS and the Delta Branch of the Mississippi Agricultural and Forestry Experiment Station. In a 3-year comparison with standard varieties in the Mississippi Delta, nectariless types reduced numbers of Lygus bug nymphs by 45 percent and of adults by 26 percent. This reduction in population reduces the amount and number of applications of chemical pesticides needed to control these damaging plant bugs and also permits buildup of beneficial predators that help control the cotton bollworm and the budworm. In 1981, a commercial nectariless variety, selected by a private seed company, but based on the germplasm developed and released by ARS and Mississippi, was planted on 11 percent of the U.S. cotton acreage.

Superior Varieties of Oilseed Crops Developed in Breeding Program

The oilseed research program is designed to improve production efficiency by developing new and improved genetic resources and cultural and management practices. The goal is to develop germplasm having such favored characteristics as multiple-pest resistance, adaptation or resistance to environmental stresses, high yield, and adaptation to mechanized culture harvesting and handling. In addition, improvement in quality characteristics such as reduced

content of undesirable constituents and enhanced nutritional value are sought. The research efforts of ARS scientists, in cooperation with the States and other appropriate agencies, have led to the discovery, development, or release of germplasm/breeding lines/varieties of improved soybeans, peanuts, sunflowers, and guar. In addition, the germplasm collections--an invaluable genetic bank of material for evaluation of quality characters that have potential for incorporation into future breeding lines--have been expanded. Evaluation of the soybean germplasm has yielded lines that show superior tolerance to excessive micronutrients, resistance to budblight and soybean mosaic viruses, high protein content, and reduced levels of linolenic acid.

New Cane and Beet Cultivars Revitalize U.S. Sugar Industry

The ARS program on the breeding and productivity of sugar crops has led to major contributions to the economic viability of sugar production systems through the development of improved clones and cultivars. This research culminated in record yields of sugar per acre of cane in Louisiana in 1981. The continued improvement in the sucrose content of cane in Louisiana and the increased number of ratoon crops in Florida have saved the domestic cane sugar industry from possible extinction. The major improvement in sugarbeet production has been the discovery and development of sugarbeet germplasm with combined resistance to Cercospora leafspot and curly top disease. These two diseases are responsible for major losses in sugar production. Without disease resistance, the continued production of sugar from sugarbeets in the United States would be in jeopardy.

Cold-Tolerant Buffelgrass Developed by Unique Methods of Reproduction

Buffelgrass, which is grown extensively for forage in South Texas and Mexico, is drought resistant and productive, but lacks cold tolerance. Cold tolerance from buffelgrass germplasm originating in Africa has been incorporated into existing U.S. lines, thus extending the area of adaptation further north. Buffelgrass is apomictic: its seeds develop without fertilization. Thus, all progeny are like the parent plant. Apomictic reproduction is an advantage in developing an improved line rapidly, but it is a disadvantage because plants with desirable traits, such as cold tolerance, cannot be crossed. Recent discovery, however, of a sexual plant and of plants that are both asexual and sexual enables selection of buffelgrass plants with desirable agronomic traits. Those plants then reproduce asexually, thus saving time and effort in developing improved lines.

New Variety of Drought-Tolerant Range Grass Developed

A new variety of drought-tolerant bluestem range grass has been released as a result of cooperative research between ARS and Oklahoma Agricultural Experiment Station scientists. The new variety has greater winter hardiness, early spring growth, and drought tolerance than other selections of the same species. In wet years the new variety yielded slightly less than other bluestem selections, but in a dry year it yielded 32 percent more. The performance in field studies correlated well with laboratory measures of photosynthesis and transpiration. Thus, selecting plants for improved water-use efficiency from laboratory studies could significantly enhance the identification of improved germplasm and speed up the development of drought-tolerant varieties. Developing plants for improved water-use could have a significant impact upon stabilizing forage production over time and make greater use of the limited water supplies in the Southern Great Plains.

Productive Range Grasses Developed

Quackgrass (Agropyron repens), a species that occurs in all temperate and subarctic regions of the world, is aggressive and usually considered a weed because of its vigorous spreading habit. However, crosses of quackgrass with related species--such as crested wheatgrass, blue bunch wheatgrass, and thick spike wheatgrass--are being developed by ARS scientists. These new hybrids have great potential for increasing the productivity of our rangelands. From these crosses, plants have been selected with the desirable features of both parents but without the aggressive spreading habit. This accomplishment is based, in part, on more than 15 years of intensive cytogenetic analyses of chromosome pairing in more than 100 interspecific and intergeneric hybrids. This basic work has resulted in correcting taxonomic relationships in important grass species and has provided plant breeders with useful new techniques and new breeding material.

National Plant-Germplasm System Serves World Scientific Community

Plant sources of genetic diversity, particularly wild species or primitive varieties that may contain genes for pest resistance and other desirable traits, are rapidly being depleted, displaced, or abandoned. Once lost, they will never again be available. The preservation, evaluation, and distribution of the broad array of germplasm and the awareness of the needs of breeders for introduced germplasm rest with the National Plant Germplasm System (NPGS), a coordinated network of institutions, agencies, and research units in the United States that work cooperatively to introduce, maintain, evaluate, catalog, and distribute all types of plant germplasm. The key elements of NPGS include

principal centers and working collections, as well as a large group of Federal, State, and private plant-germplasm curators throughout the United States. The System's unique function is to provide germplasm to the scientific community.

Groundwork Laid for 21st Century Agriculture

ARS scientists at the University of Wisconsin succeeded in transferring a gene that directs the production of a major protein from its native location in the French bean seed into the foreign environment of a sunflower cell. They call the new plant tissue "Sunbean." The gene is stable in its new environment and is producing messenger ribonucleic acid (RNA) --the material that carries genetic information from the genes to the protein-synthesizing machinery of the cell.

In the model genetic transfer system, the bean deoxyribonuclic acid (DNA) that contains the gene for the major protein, was inserted into a bacterium (Agrobacterium tumefaciens) adjacent to the DNA that transfers genes from the bacterium to the host plants that it infects. Bacteria containing implanted bean DNA then were cultured and allowed to multiply and produce colonies. The DNA was extracted from the bacterial colonies, isolated from the extract, and fragmented. The DNA fragments were sorted according to size, and fragments containing the gene that directs protein production in the bean were transferred into cultured sunflower tissue.

Possibly this model genetic transfer system is the first step in creating genetic variations that now are unknown because of sterility barriers between species and genera. This groundwork might well become the foundation for the technology of the geneticists and breeders of the 21st century.

Beltsville Bee Diet Economically Maintains Colonies of Honey Bees

The Beltsville Bee Diet was developed by ARS scientists as an economical pollen substitute that would supply adequate proteins, lipids, vitamins, and minerals to honey bees. Use of a suitable substitute would: (1) produce large populations for pollination, honey production, queens, and package bees; (2) aid in the recovery of colonies damaged by exposure to pesticides; and (3) enable beekeepers to hold colonies in strategic locations for quick mobility to crops for pollination and honey production.

This substitute diet, with high-protein lactalbumin and yeasts, supplies all nutrients essential for normal development of the honey bee colony. The substitute costs about 75 percent less than pollen, which sells for $8 per pound.

The Beltsville Bee Diet, which now is available commercially, is superior to other artificial diets and approaches the biological effectiveness of pollen. Bees pollinate over 90 U.S. crops valued in excess of $10 billion, and they produce an annual honey crop valued at $100 million. Widespread use of the Beltsville Bee Diet should help to economically maintain populations of pollinating honey bees, an essential segment of U.S. agriculture.

Machine Developed for Efficient Planting of Fruit Trees and Bushes

ARS research engineers developed a rapid, precision planter for fruit trees and small fruit plants that greatly reduced the cost of replanting orchards to new and improved stock. When breeders developed new, semidwarf fruit varieties within the past 10 years, orchardists were faced with the problem of the great cost of replanting, aggravated by the fact that the semidwarf varieties were intended to be planted at much higher densities than standard varieties. The planter developed in ARS is inexpensively manufactured and requires a tractor with only 70 to 100 horsepower. With the planter, one operator and one tractor driver can plant 400 to 500 trees per hour. The planter has reduced by about 80 percent the estimated cost to the grower of replanting an orchard. Survival rate of machine-planted trees was 99.5 percent for the first year of vegetative growth, 30 percent higher than the survival rate of hand-planted trees. Also, rows were straighter with machine- than with hand-planted trees. The planter, in use coast-to-coast, is now manufactured by at least four companies that have produced between 500 and 1000 machines. One major nursery now acts as a distributor for one model, thus providing a package sale to the grower, who also buys his replanting stock from the nursery. Manufacture and use of the planter are increasing.

New Attractant To Fight Bagworms Is Discovered

A 3-year intensive research effort by ARS scientists has resulted in the identification and synthetic production of a compound that is highly attractive to male bagworm moths. This important discovery may allow homeowners and nurserymen either to trap males in massive numbers or to disrupt the reproductive behavior of the insects. Bagworms, which are destructive pests of evergreens and many other plants, cost the public millions of dollars annually in costs of direct control and replacement of plants killed or severely damaged by repeated attacks.

Areawide Management of Cotton Insects in Trial Program Leads to Elimination of Boll Weevils

The technology to eliminate reproduction of the boll weevil in a geographically defined area has been developed and demonstrated by ARS and cooperating State and Federal agencies. The combined and coordinated use of diapause control methods, pheromone traps, sterile males, and an insect growth regulator in a 3-year trial program eliminated the boll weevil. Elimination of the boll weevil, combined with improved control of the bollworm and tobacco budworm, both important insect pests of cotton, reduced farmer costs for insect control on 40,000 acres of cotton by 70 percent. This trial and other areawide efforts have prompted the National Academy of Sciences Committee on Cotton Insect Management to conclude that areawide boll weevil management is preferred to uncoordinated management by individual growers. The success of the large-area boll-weevil trial indicates that areawide management may be an effective approach for dealing with other important insect pests.

Plant Germplasm With Natural Resistance to Important Pests Developed and Released

ARS scientists, from 1979 through 1981, have developed and released plant germplasm with resistance to the following insect pests: The fall armyworm, corn earworm, southwestern corn borer, and maize weevil in corn; the sunflower moth and stem weevils in sunflowers; the Mexican bean beetle, soybean looper, corn earworm, tobacco budworm, and cabbage looper in soybeans; the Hessian fly, cereal leaf beetle, and aphids in wheat; the spotted alfalfa aphid, blue aphid, pea aphid, potato leafhopper, blotch leafminer, and alfalfa weevil in alfalfa; the chinch bug in pearl millet; the chinch bug, greenbug, and sorghum midge in sorghum; the sugarbeet root maggot in sugarbeets; the sugarcane borer in sugarcane; the fruit fly in reed canarygrass; and the rice water weevil in rice. As resistant plant germplasm is developed, it is released to commercial and publicly supported plant breeders for incorporation into high-yielding, adapted varieties for public use.

Sex Attractant Technology Developed for Major Insect Pests

From 1979 through 1981, ARS scientists identified, synthesized, and formulated potent sex attractants for the following important insect pests: Corn earworm (bollworm), tobacco budworm, lesser cornstalk borer, western corn rootworm, northern corn rootworm, southern corn rootworm, armyworm, western yellowstriped armyworm, beet armyworm, citrus cutworm, western avocado leafroller, yellowheaded fireworm, cranberry girdler, cranberry fireworm, artichoke plume moth, bagworm, alfalfa looper, omnivorous looper, navel orangeworm, filbertworm moth, grass seed gelechiid grape moth, Asian cornborer, rhododendron borer, blue Hylaeus Australian bee, white peach scale, Comstock mealybug, citrus

mealybug, alfalfa seed chalcid, and screwworm. These accomplishments were made possible by fundamental advances in analytical chemistry and in analysis of insect behavior. The above pests cause losses in excess of $2 billion per year. This pheromone technology will be instrumental in reducing these losses.

Parasitic Wasps Found Effective in Controlling the Alfalfa Blotch Leafminer in Alfalfa

The alfalfa blotch leafminer (Agromyza frontella), a small introduced fly that has become a serious pest of alfalfa in 15 Eastern States, causes losses of about $15 to 20 million a year, or about 7 percent of the annual yield of alfalfa. As part of a biological control program, started in 1973, natural enemies (parasites) of the fly were shipped from Europe to the United States in 1974. By 1978, three species of tiny exotic wasps were established in the Eastern United States. By the first cutting of alfalfa in 1980, control of the fly was significant; and by the second cutting in 1981, the parasites were controlling the fly. This is an excellent example of an ideal biological control program. Ultimately, it is believed that the fly will be reduced to a nonpest status in the United States, as it now is in Europe.

Unusual Fungi That Attack Pathogenic Fungi Discovered

Three new mycoparasites--Sporidesmium, Teratosperma, and Laterispora--that destroy the survival structures of numerous soilborne plant pathogens have recently been discovered and show promise as biological control agents for substantially reducing serious plant diseases in various crops. Sporidesmium, the most potent parasite, is effective against two widespread pathogens which cause severe economic losses of many vegetable, oilseed, and forage crops throughout the United States. Applying this beneficial mycoparasite to field plots of lettuce reduced the population of soil pathogens by 94 percent within 6 months. In the absence of any other soil treatment, the mycoparasite provided 83 percent disease control in two consecutive crops in 1979 and 1980.

Major Advances Made in Weed Control

ARS scientists, in cooperation with scientists of the North Dakota Agricultural Experiment Station, developed outstanding chemical, cultural, and crop rotation practices to combine with integrated weed management systems for the control of wild oats in wheat, barley, sunflower, soybeans, and other crops grown in the North Central States. This technology has cut losses caused by wild oats by 75 percent, resulting in a net annual increase in farm income of more than $500 million annually for the past 3 years.

ARS scientists also developed an improved method for synthesizing large quantities of strigol, the potent naturally occurring growth regulator which causes witchweed seed to germinate. This breakthrough will provide the first opportunity to evaluate the usefulness of this growth regulator for witchweed control under field conditions and provide improved witchweed control technology for use by Animal and Plant Health Inspection Service in its efforts to contain and eradicate witchweed from the 31 counties now infested in North Carolina and South Carolina.

Agricultural Chemicals Studied

In 1981, ARS scientists evaluated more than 100 new chemicals for their effectiveness and safety as herbicides, fungicides, nematicides, insecticides, and plant-growth modifiers. This basic research provides data for establishing finite tolerances of pesticide residues in food crops and supports the minor-use-pesticide registration program conducted by ARS and the States. This research has resulted in registrations of several new pesticides and extended the registered uses of many of those currently available. This research also provides major support for the ARS pesticide impact assessment program.

High-Precision Sprayers Prevent Variations in Pesticide Application Rates and Losses Due to Leftover Pesticide Mix

In the past, the rate of pesticide application varied as sprayers speeded up or slowed down in the field. ARS research engineers have developed several new types of sprayers which greatly increase the precision and control of pesticide usage. In the new sprayers, pesticide concentrate and water (the diluent) are held in separate tanks and are delivered into the pipe leading to the spray nozzles. The concentrate is delivered into the pipe at a rate proportional to the travel speed; hence, variations in application rate due to speed changes are prevented. The pressure of the diluent in the pipe is unchanged, however, because the diluent is delivered at a constant pressure; hence, droplet size and spray pattern remain constant. One type of sprayer built for orchard use also completely surrounds the tree, preventing blow-through of the spray. A more advanced version of this type of sprayer now uses an infrared sensor to continuously measure the organic matter of the soil and to automatically adjust the pesticide spray rate accordingly. Because the sprayers handle the concentrate and diluent separately, there is neither leftover tank mix nor the problem of having to dispose of leftover mix. Sprayers of this type are now entering the commercial market.

Weeds Suppressed Through Enhanced Competitiveness of Forages in Conservation-Tillage Systems

Conservation tillage, which includes minimum tillage and no-tillage, offers a practical way of controlling erosion and maintaining the quality and productivity of soil used for crop production. The land is left unplowed, and crop residues are left on the land to help control erosion. Legumes planted by conservation tillage methods have been established successfully and have given yields equal to or greater than those produced under conventional tillage management. Probabilities of successful establishment exceed 90 percent if appropriate herbicides are applied at the proper times; i.e., at one or more of the following times: after silage, corn, or small grains are harvested; before planting, to kill cover crops; during planting of the crop in newly formed drills; or after planting. The methods allow planting later into spring and earlier in middle and late summer. These findings can greatly promote conservation of energy and soil at reduced overall cost to the farmer.

Programs based on the integrated use of herbicides, fertilizers, and planting equipment have been developed to establish birdsfoot trefoil and clovers in pastures and sods. Because of these programs, the percentage of successful establishments in sod has nearly doubled in the last 5 years. Farmers now have economically feasible options for no-tillage planting of these legumes and can benefit considerably from reduced energy requirements.

Alfalfa can be established successfully in sod if the vegetation is controlled by herbicides and if a combination of molluscicide and insecticides is applied at planting. If the combination treatments can be made economically feasible, the probability of successful no-tillage alfalfa establishments in sod may rise dramatically.

Multiple-Disease-Resistant Beans Developed for the Tropics

ARS scientists, working in close cooperation with scientists of the University of Puerto Rico, are successfully combining multiple-disease resistance with high yield and adaptability for the major bean types of the tropics, using widely divergent germplasm from worldwide sources.

Two significant new sources of disease resistance in the common bean (*Phaseolus vulgaris*) have recently been isolated. One of these sources has an apparent immunity to all races of bean rust. The other is highly resistant to all strains of common bacterial blight (*Xanthomonas* spp). Rust resistance comes from an old tropical land race of beans which has maintained its resistance for many years, and bacterial blight resistance comes from the Scarlet Runner bean, *P. coccineus*, through an interspecific cross. These two

resistances are now being combined into a single multiple-disease-resistant breeding line that can be used by U.S. and foreign bean improvement programs.

The new germplasm generated by this research is important to major bean-improvement programs throughout the United States. Federal and State research cooperators in Michigan, Wisconsin, Washington, New Jersey, Florida, South Carolina, Maryland, and many areas in the tropics have received advanced lines from this program and are finding the high vigor and disease resistances extremely useful in their breeding programs. Transfer of present disease-resistant genes into snapbean cultivars shows great potential for successful production of this crop in small-scale farming operations in the hot, humid tropics.

Substitute Crops Developed To Replace Opium Poppy in Thailand

The ARS crop substitution program for opium poppy in northern Thailand has provided information about enough crops to begin encouraging the growing of these crops by hill farmers. Crops that are ready for adoption by the tribal growers include cut flowers, bulbs, flower seeds, strawberries, peaches, pears, persimmons, pyrethrum, chrysanthemum, tea, and coffee. Teaching hill tribe farmers to grow these high-return cash crops is expected to accomplish the following goals: (1) Markedly reduce opium poppy production; (2) increase cash income to tribal villagers; (3) improve standard of living, thus reducing the disparity between tribal and other rural peoples in Thailand; (4) establish a more stable agricultural system of farming; and (5) conserve the valuable land and water resources of the highlands.

Studies Made To Control Indian Gypsy Moth With Parasites

A significant part of the Department's international activity is the Special Foreign-Currency-Supported Research Program, administered by the Office of International Cooperation and Development. Research grants awarded under this program complement but do not duplicate ongoing domestic research activities, and they also greatly decrease the need for additional dollars to support in-house research conducted abroad.

In 1981, parasites of the Indian gypsy moth, Lymantria obfuscata, were collected in the Kulu Valley of northwestern India by personnel of the Commonwealth Institute of Biological Control, and five shipments of the collection were received in the United States. ARS scientists are studying the parasites in quarantine for their effectiveness against the gypsy moth, a serious defoliator of forest, shade, and

fruit trees and of ornamentals over much of the Northeastern United States.

Apanteles flavicoxis, a gregarious larval parasite of the Indian gypsy moth, readily attacks larvae of the U.S. gypsy moth in the laboratory and appears to have considerable potential as a biological control agent against the pest. As many as several hundred parasites can be reared on a single host. In 1981, USDA personnel made late-season releases at two sites in northern Delaware and provided colonies for experimental use by State entomologists in New Jersey and Pennsylvania.

Data Provided To Assist in Registration of Minor Use Chemicals

Registration of pesticides or other agricultural chemicals by the Environmental Protection Agency or State departments of agriculture is costly, requiring that they be tested for effectiveness and safeness. The costs for most registrations are borne by manufacturers of the pesticides, who expect to sell them in high enough quantities to realize a profit. However, many essential pesticides are used on such a small scale that their research and development costs are greater than any possible return to the manufacturer. The Minor-Use-Pesticide Program was established to aid in securing registrations for such pesticides. Information obtained in this program has been used to support the registration of products for 35 food-use needs and 548 ornamental-use needs. In addition, data available as a result of the program contributed to exemptions from the requirement of tolerances in four cases: (1) use of modified atmospheres to control stored-product insects on all raw and processed agricultural commodities, (2) use of alfalfa looper virus to control caterpillars on cabbage and lettuce, (3) use of methyl eugenol + malathion to control oriental fruit fly on all raw agricultural commodities, and (4) use of gamma radiation to control insects infesting all raw agricultural commodities.

Improved Preservation of Direct-Cut Silage Increases Nutritive Value

Hay crops for dairy cattle are often ensiled to minimize the nutrient losses that frequently result from plant respiration and weather damage when plant material is field cured, especially in the humid areas of the United States. ARS researchers established that only 10 percent of nutrients were lost from plant material treated with formic acid as it was cut in the field (direct cut); 25 percent of nutrients were lost from field-cured hay. However, considerable protein is still degraded in the silo. Recent ARS studies showed that formaldehyde prevents the protein degradation that occurs in silage fermentation. Formaldehyde is inexpensive, and its proper use in ensiling hay crops can prevent the degradation of between 100,000 and 200,000 tons of protein annually in the United States. A growth rate of over 1 kilogram per day (much more than the rate expected had the forage been conventionally prepared) has been achieved in cattle fed direct-cut silage treated with formic acid and formaldehyde.

Twinning Frequency in Beef Cattle Can Be Effectively Increased by Selective Breeding

Early results from an ARS study indicate that a twinning rate of at least 15 to 20 percent can be achieved by selection of cows with a previous history of twinning. The twinning trait is heritable. Preliminary results indicate that twinning frequency in daughters of twinning cows is about 8 to 10 percent of their dams' frequencies. The average twinning rate of beef cows is less than 0.5 percent. Thus, calf crop percentage could be increased by 8 to 10 percent by selections for twinning, with little increase in cow herd feed requirements. Studies are underway to confirm these findings and to quantify the rate of genetic progress that could be made. A high twinning rate in beef cattle would have a tremendous impact on production efficiency.

Improved Preservation Procedures Allow Increased Utilization and Export of Swine Semen

Two methods for preserving swine semen now available to swine producers for use in artificial insemination are based on research conducted by ARS scientists. Semen diluted in special extenders now can be stored at 18°C for up to 3 days. This technology is used in many private herds and is gaining greater use in commercial operations. ARS scientists are working to improve procedures for evaluating sperm quality and for freezing boar semen. Semen frozen by current techniques can be stored indefinitely, but sperm viability deteriorates somewhat. The freezing procedure developed by ARS researchers using the Beltsville Freezing Extender (BF-5) is being adopted by commercial organizations in North America to ship boar semen to more than 40 countries. This greater utilization of frozen semen to propagate sperm of high genetic potential represents a significant advance in

improving the efficiency of production in swine on a national and international basis.

Sheep Management Practices Can Increase Feed Conversion and Lambing Rates

In an ARS program to improve lamb meat production, growth rate, feed utilization, and proportion of lean to fat were superior in ram (intact) lambs to the corresponding traits in wether (castrated) lambs. Male lambs raised for slaughter normally are castrated. Raising ram lambs instead of wethers could increase the efficiency of lamb meat production by 12 to 15 percent. However, the carcass quality of ram lambs is sometimes inferior to that of wethers. ARS scientists found that testosterone-implanted wethers performed similarly to rams and there was less negative effect on carcass quality. High-energy diets were found to produce more acceptable meat products from ram lambs than did low-energy diets. Other ARS studies showed that intensive management and accelerated lambing can increase lamb crops by 30 percent.

Beltsville Poultry Semen Extender Effective in Field Trials

The Beltsville Poultry Semen Extender (BPSE) is a chemical medium that allows turkey and chicken semen to be diluted and held for short periods of time without critical loss of viability. The BPSE II provides turkey and chicken sperm cells with the proper osmotic balance, pH, chelating action, and energy so that they remain fertile for up to 6 hours at 15°C. No other extender allows semen to be held for this length of time without a significant loss of viability. Field trials conducted with several poultry producers showed that the levels of fertility were maintained when BPSE or BPSE II was used to dilute chicken or turkey semen. Turkeys in the United States are bred commercially by artificial insemination. About 3.5 million turkey hens are artificially inseminated each year at a cost of $12 million. Use of BPSE II can substantially reduce this cost. Diluting semen 1:1 with BPSE II can reduce the number of breeder toms needed by half, thus saving the industry $6 million annually. In addition, labor requirements could be reduced 30 percent, offering additional savings of $2 to 3 million annually.

Waste Digestor Produces Methane and Recovers Protein From Cattle Manure

Production of methane from beef cattle manure is economically feasible for a confined feedlot of about 8000 cattle when only methane is recovered. When both methane and protein are recovered, only 1000 cattle are needed. ARS research over the last 5 years has assessed the feasibility of converting beef cattle manure into methane and a protein supplement. The research included studies on the microbiology of producing methane, development of a mathematical model to describe the fermentation process,

development of design criteria for fermentation systems, and evaluation of the fermentor effluent as a livestock feed ingredient. This research has led to the design of a fermentor with the highest daily production rate reported (4.7 volumes of methane/fermentor volume).

Animals Preferentially Utilize Vitamin D_3

ARS research has demonstrated that cattle and other animals selectively utilize the plant and animal forms of vitamin D. These animals utilize vitamin D_3 (the animal form) more efficiently than vitamin D_2 (the plant form). For example, only 7 to 10 percent as much active metabolite is reproduced by cattle from vitamin D_2 as from vitamin D_3. Because current supplementation recommendations are based on the premise that the two forms are equally active, current practices can lead to deficiencies when vitamin D_2 is substituted for vitamin D_3. Similarly, toxicities could arise in cattle in improperly supplemented rations. These results explain for the first time much of the confusion in the scientific literature about safe concentrations of vitamin D in feedstuffs.

Vaccines for Pseudorabies and Parvovirus Infection Developed

ARS scientists have developed the technology for producing bivalent killed viruses, and demonstrated their effectiveness as vaccines, for two of the most important viral reproductive diseases in swine: parvovirus infection and pseudorabies. (Killed virus vaccines are preferable to modified live virus vaccines because they do not spread live viruses throughout animal populations.) Parvovirus infection causes significant losses from reproductive failure (resorbed embryos and stillborn or mummified pigs). Pseudorabies is a herpesvirus disease that can kill up to 100 percent of infected young swine, usually within 24 hours of onset of the disease. ARS research on these diseases focuses on improving and standardizing diagnostic testing, characterizing and identifying the different strains of virus that occur in the field, and gaining a better understanding of the epidemiology and latent forms of these diseases. The technology based on this research has been passed on to the industry. Killed vaccines are now available for use by producers, a significant achievement that provides the first opportunity both to assure shipment of superior breeder stock free of these diseases and to reduce disease incidence in infected herds.

Radioimmunoassay Developed To Test for Antibody to Bluetongue Virus

Bluetongue is a serious viral disease of livestock that has blocked export of cattle, sheep, and goats from the United States to many major world markets. Export losses due to refusal of foreign markets to accept livestock, semen, and embryos is estimated at $20 to 30 million annually. Bluetongue is particularly damaging to sheep, killing up to half of infected animals. The virus is extremely difficult to isolate. ARS scientists have perfected a radioimmunoassay procedure for measuring antibody to the virus in sheep and cattle. This procedure is presently being compared to other serologic tests for antibody determination. Radioimmunoassay is a valuable tool in research on the application of monoclonal antibody technology to the diagnosis of bluetongue in persistently infected cattle. The application of these procedures should reopen foreign markets for livestock from the United States.

Monoclonal Antibodies Offer Possible Control of Poultry Coccidiosis

Coccidiosis is a disease produced by several species of protoza that multiply inside the cells lining an animal's intestine. This disease costs poultry producers over $250 million a year because birds fail to grow as they should and require continuous medication. Recent progress by ARS scientists involves the hybridoma technique, in which a particular type of cancer cell from mice is fused with spleen cells from mice immunized with the coccidial organism. The hybrid cells can be grown in the laboratory and cloned to obtain a cell line that produces only a single (monoclonal) antibody. Hybridoma lines have been developed that produce species-specific antibodies, thus allowing a rapid and sensitive test for identifying different species of coccidia. Other antibodies have been recovered that react only with certain parts of the coccidia such as the surface. Finally, monoclonal antibodies from some hybridomas restricted growth and multiplication of the parasites in preliminary trials, thus indicating that more effective protection against the disease may be possible.

Vaccine for Foot-and-Mouth Disease Developed by Genetic Engineering

A new and safe vaccine for foot-and-mouth disease was developed by recombinant DNA technology--a form of genetic engineering in which a single gene or small series of genes from one organism are inserted into another organism. ARS scientists, working in cooperation with scientists from private industry, isolated genes from the foot-and-mouth disease virus that produce the viral coat protein, which is responsible for induction of immunity. These genes were then inserted into the cells of Escherichia coli, a bacterial species commonly used in the laboratory. These bacteria during their normal growth now produce the viral coat protein in large quantities. The protein can be extracted from the

bacteria, purified, and made into a vaccine specific for the original strain of foot-and-mouth virus. The vaccine has proved highly effective in laboratory tests for the prevention of foot-and-mouth disease in both cattle and swine. The vaccine is easy and economical to produce and exceptionally safe to use. The vaccine cannot produce the disease, for only a portion of the virus, not the whole virus, is used, and can be stored for a long time without refrigeration. This vaccine is expected to be the first of many produced with this new technology. These new vaccines will be extremely important worldwide for improving the efficiency of livestock production by controlling and reducing losses due to diseases.

Research on Sulfamethazine Reduces Residues in Pork

ARS scientists have clarified the routes of elimination of sulfamethazine, a compound fed to swine for control of atrophic rhinitis and for growth promotion. Detailed analyses of urine and skeletal muscle indicated the disposition of the parent compound and its metabolites; in addition, two previously unidentified metabolites were discovered and identified. This new knowledge, in conjunction with studies conducted in cooperation with the National Pork Producers Council and the American Feed Manufacturers Association, has revealed problems that occur in the feed-handling systems. As a result of these activities, numbers of swine with violative levels of sulfamethazine in their tissues have been reduced from 15 percent to less than 3 percent of animals tested. This new technology has helped meet the requirements of action and regulatory agencies, increased profit to swine producers, and assured consumers of wholesome and safe pork products.

Promising Eradication Technique Is Being Developed for Cattle Ticks and Southern Cattle Ticks

ARS is developing what could be a revolutionary technique for controlling two closely related tick species, the cattle tick and the southern cattle tick. These two ticks are vectors of babesiosis and anaplasmosis and are major limiting factors to the production of cattle in many parts of the world. Although these ticks have been eradicated from the United States, they are frequently reintroduced from Mexico. ARS scientists, working with university researchers, have crossmated the two species. Hybrid males are sterile; when they mate with normal females, no offspring are produced. Hybrid females have reduced fertility and produce sterile males and females with low fertility. This phenomenon is seen through three generations. The hybrid males are fully competitive with normal males in mating. The ARS technique

of release of sterile hybrid male ticks has proved accurate in mathematical models but has yet to be field-tested.

Common Protozoan Parasite of Dairy Cattle Found To Decrease Milk Production

The protozoan Sarcocystis, a common parasite of dairy cattle, until recently was considered relatively harmless. However, ARS scientists found that infection with this parasite causes abortions in cattle and sheep and reduces the quantity and quality of milk production of dairy cows. These findings have enabled the scientific community to initiate research on the development of methods of diagnosis, prevention, and control. Subsequently, a test protocol was developed that provides protective immunity in experimentally infected calves. Calves are inoculated orally with sporocysts and medicated 21 through 35 days later with an anticoccidial drug. This protocol allows nonpathogenic stages to develop at 14 days but prevents pathogenic stages from developing at 28 days. Calves challenged at 60 days with a lethal dose of sporocysts show no clinical illness.

System Developed for Monitoring and Controlling Spoilage of Stored Potatoes

A system referred to as an electronic sniffer continuously monitors the "breathing" of stored potatoes and detects abnormalities resulting from bacterial infections and rot. The system readily detects the early warning signals of bacterial soft rot; i.e. abnormal amounts of acetone, alcohol, and a ketone (2-butanone). The effectiveness of the system has been demonstrated with commercial-size bins, each containing over 1 million pounds of potatoes. Early warning will give growers the time needed to take remedial action to avoid losses. The benefit of early soft rot detection is expected to reduce by at least 20 percent the 400- to 700-million-pound loss currently suffered by growers. Other benefits expected are higher potato quality and greater efficiency in maintaining ventilation in bins.

Similar systems are being developed to detect insect activity in stored grain and spoilage of tomato and orange juice concentrates in bulk tank storages.

Composition and Stability of Soybean Oil Investigated

ARS research on controlled growth studies in a phytotron has shown that oil content and fatty acid composition of soybean plants are significantly affected by day- and night-time temperatures. As day- and night-time temperatures increased, oil content increased and linolenic acid--a polyunsaturated fatty acid believed to be negatively correlated with oil stability and flavor--decreased.

Studies on the mechanisms of oxidation of soybean oil fatty acids have shown that there are two routes by which oil stability is decreased: (1) a light-induced single-oxygen mechanism, through naturally occurring photosensitizers and (2) air-induced through a free radical mechanism. Each produces specific and different oxidation products.

These studies provide the basic information essential to the development of new varieties and alternative production, processing, and handling regimes that will assure the quality and value of soybean products in the marketplace.

New Technique Developed for Using Catfish-Processing Waste

Farm production of catfish, a relatively unknown enterprise a decade ago, is fast becoming one of the largest segments of freshwater aquaculture in the United States. Disposing of processing waste (heads, skin, fins, viscera) is a serious problem. A new method was developed to convert these processing wastes into high-quality, high-protein feeds. The process involves liquefying the waste with naturally occurring visceral enzymes that are activated by the addition of small amounts of formic acid, screening out bones after low-temperature digestion for 1 hour, removing the catfish

oil by centrifugation, and removing most of the water by vacuum evaporation to produce a high-protein feed concentrate. This concentrate can be used as an animal feed supplement or pet food ingredient, or it can be dried further to a meal. This new process offers several advantages over conventional rendering methods: lower temperatures are used; the dried meal contains 80 percent protein; energy requirements are lower because of low temperature and high-efficiency evaporators; the process is simple and requires no specialized equipment; and the process is fast. Two catfish-processing cooperatives have now built a liquefaction plant to handle their catfish- processing waste.

Products Analyzed Nondestructively by Optical Techniques

Nondestructive, optical techniques developed by ARS scientists are used for objective evaluation of the quality of agricultural commodities and products. One such technique, based on the use of near-infrared reflectance spectroscopy, provides rapid, inexpensive, and accurate estimates of the contents of such components as protein, oil, moisture, and fiber in agricultural commodities and products.

Scientists use techniques in which light transmittance is measured to evaluate fresh pears and to determine the composition of individual seeds. In several popular pear varieties, maturity and ripeness were evaluated and internal defects were detected. In individual soybean seeds, contents of oil and protein were accurately measured.

New Method Detects Field-Sprouted Grain

Field sprouting of grain is a recurring problem that greatly affects the baking quality of flour. To meet the needs of the flour industry, the grain trade, and regulatory agencies, ARS scientists developed a simple, rapid colorimetric test, based on selective enzyme activity, to detect sprouted grain. Sequential tests require about 5 minutes per sample. Collaborative studies in the United States and Canada indicate that the technique is simple, rapid, and reliable. Instrumentation for the test is commercially available, and the method has been granted First Approval by the American Association of Cereal Chemists. Work is continuing to extend the applicability of the test to all cereal grains and to malts.

Immunoassay Detects Contaminating Species in Meat Products

ARS scientists produced antibodies to myoglobin from lamb, pork, and horse muscle placed in an agar-gel diffusion. They subsequently used these antibodies in a radio-immunoassay procedure to detect the presence of meat from those species in beef products. Goat antipork myoglobin serum and rabbit antihorse myoglobin serum were used to detect those species in beef mixtures cooked to 70°C (158°F). The method also functions well in uncooked meat. Horsemeat can be detected in beef cooked to 90° (190°F). The assays are important to Federal and State regulatory agencies to assure the accuracy of meat labels and to ethnic groups that avoid certain species as food. Also, the method could help protect allergic patients who are sensitive to one or more meat species. Methods developed by this research are now used by the Food Safety and Insection Service to protect against importation of undeclared species.

Techniques Tested for Preventing Import of Exotic Pests and Diseases

Each year 25 million people arrive in the United States by air, and the numbers are increasing. Thousands of exotic plant and animal diseases and pests are found annually in agricultural products carried in arriving passengers' luggage. Animal and Plant Health Inspection Service asked ARS to develop an automated inspection system to handle the increasing traffic more effectively. A multidisciplinary team of analytical chemists, physicists, and engineers developed and tested instruments for detecting agricultural products that might carry exotic diseases and pests. These scientists, supported by extramural contracts, investigated electromagnetic sensing instruments with microwave technology, vapor-sensing instruments for detection of volatile components of foodstuffs, and X-ray imaging devices. Volatile sensing and X-ray detection were found feasible. A combination of those techniques should provide the technology essential for development of an effective inspection system.

Dietary Supplement Developed for Malnourished Children

ARS scientists have developed, tested, and prepared specifications for formulations of rice/soy/milk-blended foods for possible purchase by the Agricultural Stabilization and Conservation Service for use as a weanling food under the PL-480 program. Those formulations offer excellent potential as a dietary supplement to nutritional requirements of malnourished children in developing countries. Additional research is conducted in support of the Department's mission to develop commercial agricultural export markets. Research under this program also produces the technical capability and support for other Government agencies charged with the distribution of food abroad.

Alternative Quarantine Treatment Developed for Florida Grapefruit

Each year, $80 million worth of Florida grapefruit is exported by the United States to Japan. The grapefruit is fumigated with ethylene dibromide (EDB) as a quarantine treatment against the Caribbean fruit fly. With the possible banning of EDB for fumigation purposes in 1983, ARS scientists have developed an alternative quarantine treatment to assure that no flies infect fruit shipped to Japan. In this treatment, Florida grapefruit are cured and stored with a particular regime of temperatures. That so-called "cold treatment" kills Caribbean fruit flies and provides the Florida citrus industry with a quarantine treatment that avoids all of the regulatory problems related to the use of EDB. This nonchemical method has a potential for removing many trade barriers for the Florida citrus industry and for maintaining foreign markets for Florida grapefruit at a time when these markets are critical to the economic well-being of the industry and the Nation.

Trickle Ammonia Process Prevents Mold Growth When Feed Corn Is Dried With Unheated Air

ARS scientists have developed the trickle-ammonia process, an on-farm system for drying high-moisture grain with unheated air. This process involves intermittent application of low levels of anhydrous ammonia gas for 1 to 2 months to suppress the growth of potentially toxigenic molds. Ammonia gas is added to the grain bin at a rate of 0.5 pound per 1000 pounds of grain for each application, for no more than 10 applications. The ammonia is introduced into the blower airstream through a garden hose at little more than atmospheric pressure. At concentrations below 0.5 percent, the ammonia is not corrosive to galvanized bin surfaces, nor does it pose a hazard to the applicator. Accidental corrosion can be prevented by painting the inside of the bin with an epoxy-based resin. Current calculations show that drying costs are 5 to 6¢ less per bushel when corn is dried with unheated air and ammonia than when dried with hot air.

New Tobacco Curing Method Tested on Pilot Scale

Significant changes in the chemical properties of tobacco leaf are possible through a new process developed by ARS scientists--homogenized-leaf curing (HLC). By this process, tobacco leaf is homogenized, and the homogenate is fabricated into sheets of prescribed thickness and porosity. Before fabrication, however, precursors of undesirable constituents can be removed from the homogenate.

Pilot tests of the HLC process conducted with flue-cured and burley types of tobacco are promising. Despite removal of the soluble proteins from the leaf homogenates, the smoking quality of the tobaccos was maintained. Also, tar delivery and biological activity of the tar were reduced. Proteins

are precursors of the allegedly harmful smoking products hydrogen cyanide, oxides of nitrogen, and quinolin.

Vegetable Oils Provide Satisfactory Substitutes for Diesel Fuel

ARS has established two Agricultural Energy Centers to serve as the focus, technical coordination, and monitoring points for funds passed through to ARS from the Department of Energy. Research conducted with these funds involves development of technologies to increase the availability of woody and agricultural biomass materials for fuel alcohol production, as well as solar and wind energy research and development. ARS scientists have conducted research on the use of vegetable oils as a satisfactory substitute for diesel fuel. In addition to testing these oils for satisfactory performance, ARS has examined techniques for refining them and their suitability for use in different types of engines. The research has shown that sunflower and other seed oils have excellent potential for contributing importantly to agricultural fuel supplies in the event of a national emergency.

Advances Made in Studying Human Nutrient Requirements

Nutrition influences the functional outcome of the human potential for growth, reproduction, disease resistance, longevity, and intellectual development. We need to understand more fully the relationships between nutrient intakes and ultimate expressions of the genetic potential of humans. To accomplish this, we must define human nutrient requirements at all life cycle stages; improve human nutrition status by making available techniques to assess the effectiveness of nutrition programs; determine nutrition content of agricultural commodities and foods as eaten; and establish the biological availability of nutrients in these foods.

ARS scientists have developed and validated a new multielement analytical method for simultaneously determining as many as 16 minerals and trace elements in foods. This improved methodology will have a profound effect in enhancing ARS' ability to determine the nutrient composition of foods.

A new procedure has been developed in ARS for determining Vitamin K deficiency. This procedure detects the antibody formed when prothrombin is not carboxylated due to lack of Vitamin K. The procedure will be valuable in monitoring the nutrition status of populations at risk, as well as in determining Vitamin K requirements in the elderly. The procedure was tested by sampling a free-living population of the elderly, 10 percent of whom had indications of Vitamin K deficiency.

Hazards From Attic Solar Collectors Reduced

In research on attic solar collectors, ARS scientists found that if temperatures do not exceed 180°F, no damage occurs to the components after 5 years' operation. However, if the homeowner fails to convert from winter to summer mode operation, temperatures in excess of 300°F occur and extreme deterioration is evident after 1 year of exposure. As a result of these findings, ARS has prepared new recommendations for solar-attic construction:

1. Solar attics should be equipped with automatic vents that will open if attic temperatures reach the 150-180°F range.

2. Solar collector plates should be of metal, spaced away from flammable building materials.

3. Wood timbers and surfaces exposed to direct sunlight in the collector should be painted white to prevent excessive surface temperatures from developing.

These features are being incorporated into eight new plans that are being developed for conventional houses. These data are essential to gain acceptance of this construction practice in houses financed by the Federal Housing Authority, Veterans Administration, and Farmers' Home Administration.

Methods Developed for Detecting Small Quantities of Chemical Contaminants in Animal Food Products and Feeds

Drug and other chemical contaminants in food products of animal origin may pose a health hazard to consumers, and thus strict residue tolerances have been adopted. Animal products found to contain residues of these contaminants above tolerance levels cannot be sold for human use, with resulting economic loss to the producer. Faster and simpler methods which allow simultaneous analysis of a large number of samples are needed for detection of the residues in animal tissues. Such methods will be used by regulatory agencies and by producers who monitor the quality of the animal products they produce.

To meet this need, ARS scientists have developed the concept of visual microcolumn methods, using both small sample size and small amounts of solvent. These methods are cheap, fast, and simple. The first method was developed for sulfamethazine in swine feed. This drug has caused major problems for swine producers, since detectable residues may result when the drug is present at only 2 parts per million in the feed of pigs. The method for sulfamethazine--unique in that it removes nonamphoteric compounds--will give near quantitative estimates of 1 to 20 parts per million of the drug in animal feed. Presently these microcolumn methods are being developed for residues of chloramphenicol, diethylstilbestrol, and the nitrobenzamide coccidiostats in animal tissues.

Byssinosis Control Aided by New Equipment and Processes

Byssinosis, the lung dysfunction which some cotton mill workers suffer after exposure to dust generated during handling and processing of raw cotton, has been identified as the most serious health hazard and economic threat faced by the American cotton and cotton textile industries. The Occupational Safety and Health Administration (OSHA) has established workplace requirements for the dust in an effort to alleviate this hazard to health.

Research conducted by ARS scientists has contributed significantly to the ability of textile mills to meet the strict OSHA standards. One of the devices developed, the wet wall electroinertial air cleaner now being commercially evaluated, holds particular promise to improve the efficiency of removal of respirable dust particles from air streams.

Washing of raw cotton has been identified as another means to remove the causative agents. Extensive efforts are underway to refine this new technology to maintain the spinnability of cotton fibers while eliminating the hazardous dusts.

New Concept Developed To Protect Man From Insects

A new concept in personal protection from insects, ticks, and mites that bite, annoy, and transmit diseases to people has been developed by ARS scientists. For years, this protection involved protective clothing or the application of repellents to skin and/or clothing. These repellents deterred the approach of insects or prevented their landing to bite; they did not affect biting behavior or reduce the number of insects attacking.

Now researchers have shown that new pyrethroid chemicals such as permethrin stop biting behavior and actually kill attacking insects, ticks, and mites after only momentary contact with the chemical. Incorporation of the material in clothing or surface application from aerosol cans has provided protection against ticks, mites, mosquitoes, stable flies, and tabanids. This new method not only protects from but also reduces the attack for a variety of biting arthropods. Four States have now approved and labelled the compound and the method for use, and full registration is anticipated. The Department of Defense is currently considering the incorporation of treated clothing into the military supply system for protection of troops. The new method reduces the costs of such protection by two-thirds, is safe for humans, and does not contaminate the environment. It combines the requirement for protecting people, with the bonus effect of simultaneously reducing the attack rate. The new treatment survives exposure to the elements and to sweating, as well as to rinsing and washing, and will provide much longer protection (weeks to months) than repellents used previously (minutes to hours). This new approach to personal protection can be combined with the use of an insect repellent such as Deet, which is applied to exposed skin, and it has the effect of extending the time of the repellent's effectiveness.

INDEX

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